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Spain joins the SKA.

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Abstract

The Square Kilometre Array (SKA) is an international project, qualified as ESFRI (European Strategy Forum on Research Infrastructures) Landmark, to build the largest and most sensitive radio telescope ever conceived, with the potential to achieve fundamental advances in Astrophysics, Fundamental Physics and Astrobiology. Since 2011, the IAA-CSIC coordinates the Spanish participation in the SKA. **On last 1st June 2018 Spain became the eleventh member of the SKA Organisation**. In the following sections, we summarize the process that has been followed in Spain to achieve it.

1 Introduction

SKA is being built in order to address open key questions in several areas, such as Astrophysics, Astrobiology and Fundamental Physics. Some examples of them are: the formation of the 1st galaxies in a dark Universe dominated by atomic gas, the evolution of the atomic gas and the star formation till the current epoch, strong field tests of gravity using pulsars and black holes, understanding the acceleration in the expansion of the Universe, or the study of extrasolar planets and their formation through proto-planetary disks, or the presence of biomarkers.

All of these questions have several aspects in common, which may be translated, from an instrumental point of view, on requirements such as the capability of detecting ultrafaint radio signals in a large bandwidth (MHz to GHz, e.g. 21cm HI line), high angular resolution and high survey speed.

All these requirements led to the development of an instrument like the Square Kilometre Array, an interferometer with a total collecting area equivalent to 1 square kilometre. This is achieved by combining thousands of antennas with different technologies that cover a wide frequency range. The antennas are separated by thousands of kilometres, located in up to 9 countries in Africa (starting in South Africa) and Australia (starting in the West of the country). Technically, it may be considered as a sensors network at a continental scale.

The SKA Observatory will be a single observatory organised in three sites i.e. the headquarters (located in United Kingdom) and two telescopes in different continents.

1.1 SKA1

SKA is an interferometer, hence it allows for a phased development. The first phase of SKA (SKA1) is currently at the end of its design phase. SKA-low will consist of 131.000 dipoles in Australia covering ranges from 50 to 350 MHz (low frequencies), reaching baselines of 65 km. SKA1-mid will consist of almost 200 dishes in South Africa (including 64 MeerKAT dishes), covering ranges from 350 MHz to 14GHz and with baselines of 150 km.

The cost cap for the deployment baseline of SKA1 is €674 M (financial value of 2016) and it will enter into the procurement phase in 2020-2021, with construction expected in the period 2021-2027. Early Science is planned to start by 2026.

1.2 SKA2

SKA2 (to be developed in the period 2024-2030) will increase the number of dipoles and dishes (approximately 500.000 dipoles + 2500 dishes) of SKA1, that will extend to baselines of up to 3500 kms, as well as improve other capacities based on what is called an *Advanced instrumentation program*. It will include achieving lower frequencies (200 - 500 MHz) and larger fields of view with approx. 250 dense aperture array stations, as well as by adding Phased Array Feeds (PAF) to the dishes, and aiming to reach extremely wide bandwidths.

1.3 International (and European) Context and Organization

The SKA Organisation (SKAO) is currently composed of 12 member countries: Australia, Canada, China, France, India, Italy, New Zealand, South-Africa, Spain, Sweden, the Netherlands and UK, being Spain and France the last 2 to join the project, in June and July respectively. But this project goes much further, counting with the involvement of many other countries: Brazil, Japan, Malta, South Korea, Poland, Portugal, Russia, USA, Germany, Switzerland, Mexico, Ireland, Russia. In short, it involves more than 1000 scientists and engineers from more than 270 institutions and 20 countries.

2 SKA in Spain

The Spanish participation in the SKA started with the participation of the U. Alcalá-IGN and U. Valencia in the FP6 Project SKADS (SKA Design Studies, 2005-2009). In 2010, the MICINN qualified the project as *high-priority* in its roadmap. After that, in 2011, the RIA meeting *Science and technical opportunities in the SKA era* showed a broad and strong scientific interest of Spanish researchers in the SKA. This interest kept growing making possible that the MICINN applied for Spain to become an SKA Observer country in September 2011. Since then, other SKA-related projects/scientific networks have been carried out: from 2011

to 2014, the *Spanish Scientific Network of SKA* (FIS2011-14593-E, PI. J. C. Guirado, U. Valencia) funded by the MICINN, counted with 6 research institutions and 5 universities.

In December 2011, the project *VIA-SKA: Feasibility study of the Spanish participation in the SKA* started, led by IAA-CSIC, and gathering 7 research institutions plus 8 Universities that worked together in the elaboration of a feasibility study and promoted the participation of Spanish companies and academic centres in the SKA design.

Several activities beyond the original scope of the VIA-SKA project have been performed during these years, such as: a) Diffusion and organisation of SKA activities in coordination with the SKA Communication and Outreach Network (SKACON), including the support to the organization of meetings and conferences, conferences in research centres, outreach talks, maintenance of the SKA Spanish website, called minisite, or diffusion in media; b) Support to academic groups, industry and the Ministry, including interaction with design consortia, the SKA Office, support to apply at funding calls and coordination of proposals, or support to the incorporation to SKA committees/Science Working Groups/Key Science Projects/design Working Packages; c) Creation of the capacity map of Spanish industry, preparation for the procurement phase (in collaboration with CDTI), and d) Joint discussions with international SKA related stakeholders.

2.1 SKA Science in Spain

In terms of Science, we highlight the effort made in the preparation of the **Spanish SKA White Book** [1] in 2015, where 120 researchers from 40 centres participated in 29 chapters, covering most of the areas mentioned in the SKA Science Book [2]). This last book counted with the participation of Spanish researchers in more than 14 chapters, representing approximately a 10% of the book.

2.2 Preparatory work: precursors and pathfinders

Spanish researchers also participate in preparatory works with SKA precursors and pathfinders. Precursors are those radio telescopes that are located in the sites where SKA will be established, while pathfinders are those that are testing some of the technologies that will be used in SKA. This will allow our community to get prepared for the scientific data analysis when SKA will be fully operational. Since SKA will not be only an instrument for radioastronomers, it is of relevance to consider the synergies with instruments working at different wavelengths, like those performing optical 3D spectroscopy.

2.3 Workshops, Conferences and Meetings

In the last years, several workshops, conferences and SKA related meetings have been organized. In 2012, the SKAO visited Abengoa facilities, and in 2016, the Plataforma Solar de Almería (PSA-CIEMAT) with the aim of making the SKAO aware of the Spanish expertise in renewable energies. In November 2012, the workshop *SKA: Strategic Position & Future Opportunities for Spanish Industry* took place, with more than 50 companies and academic

centres involved. **In October 2014, a Spanish SKA Day was held at the IAA-CSIC**, with 18 institutions and 17 companies participating. **In February 2016, an SKA Industry Day was organised by CDTI, the SKAO and IAA-CSIC**. It counted with 80 participants, including the attendance of the SKA Director General and SKA design consortia leaders. In November 2017, the meeting *Physics opportunities with a new universes view: the SKA radio telescope* was held in Valencia and, last May, the *VI Meeting on Fundamental Cosmology* counted with 4 talks related to SKA.

2.4 Membership in SKA Committees

Spanish researchers participate in several SKA committees and in positions and representation in boards of the SKA Organisation or SKA Consortia, such as the following:

- SKA Power Supply Option Working Group
- Spanish Liaison Industry Officer (ILO)
- Boards of SKA design consortia (Dish, SaDT, SDP)
- Dish consortia
- SKA Regional Centre Coordination Group (SRCCG)
- SKA Communications Steering Committee (SKACOSC) and SKACON
- SKA Office (SKAO)
- Science Working Groups (SWGs). currently 28 researchers from 11 Spanish institutions participate in 9 out of the 11 SKA SWGs, with 2 of them acting as co-chairs

2.5 Technological developments for SKA Design

In March-June 2013 a Request for Proposals was issued by the SKA Office corresponding to the work packages to be established for the design of SKA. As a result, 12 Spanish research centres and 12 companies participate in 8 SKA international Preconstruction Consortia (contribution estimated at approximately €2M in Feb 2014). More recently, Spanish research centres have been invited to join the PAF consortium whose activities will continue during the SKA1 Construction.

2.6 Industry capacity map

In the context of the VIA-SKA project, the IAA-CSIC elaborated in 2013 the capacity map of Spanish industry for the SKA design and construction. This was the beginning of several activities related to industry:

- In April 2013, a report called *VIA-SKA: Feasibility study of the Spanish technological participation in the SKA* was presented to MINECO and the RIA, based on the above mentioned capacity map.

- From January to October 2017 a revision of potential contracts for the Spanish Industry was done in collaboration with CDTI, when the SKA ILO from CDTI made a survey to the Spanish industry for construction contribution.

- In May 2018, a **response to an SKA Construction Request for Information** was prepared by CDTI in collaboration with IAA-CSIC.

2.7 Milestones

We can summarize the performed activities in the last years with the following milestones:

- In January 2012, 9 VIA-SKA members entered in the Work Breakdown Structure Working Groups.

- Since October 2013, a MINECO representative has been regularly invited to the SKA Board meetings.

- In January 2014, the RIA Board endorsed the recommendation issued by the G1 RIA committee in November 2013 on the interest of joining the SKA before SKA construction

- In February 2014, the Spanish participation in SKA design was valued in 2M€ by SKA.

- **In December 2015, a letter from the Secretary of State to SKA DG started a dialog to explore scenarios for Spain to join the SKA**.

- In 2016, SKA was included in the Spanish National budget.

- In June-July 2016, a report was produced for **the Evaluation of the participation of Spain in the SKA** and submitted to the Secretary of State; **the outcome was positive**. This action was followed by on-going negotiations with the SKA DG and Board.

- July 2017 - June 2019. RED-SKA: Excellence network for the scientific and technological participation of Spain in the SKA -AYA2016-82017-REDT. Coordination: IAA-CSIC. Participants: CAB-CSIC, ICE-CSIC, IFCA/DICOM, Universidad de Valencia, BSC, UPM, UGR, IAC, CIEMAT-PSA.

- From July 2017 to June 2019, the RED-SKA project is being developed: Excellence network for the scientific and technological participation of Spain in the SKA -AYA2016-82017-REDT. Coordinated by IAA-CSIC, it counts with the participation of CAB-CSIC, ICE- CSIC, IFCA/DICOM, Universidad de Valencia, BSC, UPM, UGR, IAC and CIEMAT-PSA.

- In May 2018, the Secretary of State sent to the SKA Organisation the official request for Spain to become Member of the SKA Organization.
- **Since 1st June 2018, Spain is the 11th Member country of the SKA Organization.**

3 Conclusions

Spain has developed a solid scientific community, strategically positioned within the SKA project, working in close collaboration with engineers and industry, ready to play a major role in SKA1 Key Science Projects, and also performing key contributions to the SKA design phase and construction, with an impact in society. As a consequence of these efforts, Spain has become a Member of the SKA Organization. This is of special relevance since SKA is an ESFRI Landmark project with the potential for transformational science that will lead to a scientific revolution beyond radio astronomy. This will imply I+D+i in cutting edge technologies, and will attract the best scientists, engineers and managers.

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References

[1] The Spanish Square Kilometer Array White Book. Editors: M. Pérez-Torres, L. Verdes-Montenegro, J.C. Guirado, A. Alberdi, J. Martín-Pintado, R. Bachiller, D. Herranz, J. M. Girart, S. Migliari, J. M. Rodríguez-Espinosa. 2015. http://spain.skatelescope.org/ska-science/libro-blanco-ska/

[2] Advancing Astrophisics with the Square Kilometre Array. PoS 2015 New official SKA science book, 2000 pages. https://www.skatelescope.org/books/